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Immersed in marvel

New Tyne tunnel showcases industry innovation

Tunneling under the River Tyne in the United Kingdom has a history that goes back to the 1950s, when a pedestrian and bicycle crossing was created to provide workers with better access to jobs in the shipbuilding industry on both banks of the river.

The original Tyne tunnel, which was used by more than 16,000 travelers per day soon after it opened in 1951, was followed with a vehicular tunnel that opened in 1967 and was considered an engineering feat at the time.

With approximately 36,000 vehicles traversing the existing vehicular tunnel each day, exceeding its designed capacity by more than 30%, a second tunnel is needed to alleviate congestion and create favorable conditions for public transport links.

A new engineering marvel, incorporating some of the most innovative tunnel-design techniques known in the business today, is now under construction. Scheduled for completion in December 2010, the $171 million project is being executed under a 30-year design-build-finance-operate-maintain concession financed and developed through a public-private partnership with concessionaire TT2 (Tyne Tunnel 2) Ltd. The concessionaire is responsible for operating the tunnel until 2037 and for refurbishing and operating the existing auto tunnel as well as the pedestrian and bicycle passage. Parsons Brinckerhoff is one of three main designers to the contractor, Bouygues Travaux Publics.

Once the new tunnel is complete, the old one will be closed to traffic, refurbished and reopened in late 2011. Ultimately, one tunnel will handle all southbound and the other will carry all northbound traffic.

The new tunnel will be only the second immersed tunnel in all of England, the other being the River Medway Tunnel in Kent. Linked at either end to deep cut-and-cover tunnel sections, the northern approach will be 1,050 ft long and the southern approach more than twice that, 2,700 ft. The fact that the northern approach tunnel crosses over the existing tunnel with less than 10 ft of clearance presented one of the greatest engineering challenges, since the weight of the ground above had to be temporarily removed, posing the risk of heave of the existing tunnel due to unloading.

In addition to the tunneling project, major infrastructure work was required on local roads, especially on the newly created Jarrow interchange, which also houses the ventilation plant for the tunnel. The existing road bridge, which spans the top of the old tunnel, will be demolished and replaced with a new loop road.

A dictionary of tunneling techniques

The geology along the alignment of the immersed tubes includes localized alluvial river silt and alluvial sand and gravel (including a buried channel from a former course of the river), which is underlaid by the local dominant glacial deposits. These glacial deposits include strong stony lodgement tills that are interbedded with weaker laminated (varved) clays and glacial sand and gravel. Bedrock is interbedded sandstones, mudstones, siltstones and coals. These complex site conditions required the wide range of tunneling techniques employed in this project.

Most of the approach tunnel sections were constructed using cut-and-cover and diaphragm walls. Trenches were excavated on each side of the tunnel alignment, in some cases 98 ft deep, and temporarily supported by bentonite slurry. Steel reinforcement was then lowered into the trench and concrete piped in to replace the bentonite. After the concrete had cured, the tunnel area between the two diaphragm walls was excavated while temporary props between the walls helped them withstand the high ground pressures experienced during deep excavation. Once the concrete work on the floor and roof slabs has been completed, these props will be removed and the excavation backfilled over the tunnel.

In the shallower approach sections in the south, and where groundwater conditions were less problematic, contiguous piled walls were used in lieu of the diaphragm walls, with a reinforced concrete box constructed between the piled walls. The shallowest part of the southern approach is constructed in open excavation as a reinforced concrete open-cut box.

Rather than tunneling the river section in the traditional sense, some 484,000 cu yd of the riverbed were dredged and four 39- x 33- x 295-ft caissons floated into position by tug boat. To sink them into the dredged tunnel, ballast tanks were filled and a shield of rock armor was added to prevent damage from dragging anchors. Total excavation volume is estimated to reach 523,000 cu yd although the surplus material has been reused to backfill a nearby dock, which has created a significant regeneration benefit.

To avoid the disruption of major utilities, two short stretches at the south end were bored using umbrella vaults,

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Workers excavate the tunnel area between the two diaphragm walls. Temporary props between the walls helped them withstand the high ground pressures.

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steel arches and sprayed concrete lining rather than open excavation. The latter involved boring out the material from below ground and spraying the space with concrete as the excavation proceeded in order to support the excavated space. This is a safe and well-established technique enabling utilities and certain roads to remain undisturbed by construction activity. The sprayed concrete-lining sections comprise an outer sprayed concrete primary lining and an inner cast in situ permanent lining.

Once complete, both tunnels will provide escape passages that can be accessed via emergency doors from the main traffic cell. This is a departure from the reference design, which suggested that emergency escape from the existing tunnel should be via escape tunnels connected to two large shafts. This would have been very difficult to build and maintain. Therefore, a way of engineering a common escape passage was developed for the existing tunnel. This involved retrofitting an escape passage and is considered to be a significant safety improvement.

Salmon and seagulls as stakeholders

Given Newcastle's history as an industrial center, local authorities were especially concerned about mitigating the environmental impacts of the project. It was decided a proactive approach was required and regular meetings were scheduled with stakeholders throughout the construction process. This close communication helped gain the confidence of the responsible parties who were willing to delegate authority to individual officials. This meant specific issues could be addressed immediately without having to wait for scheduled committee meetings. As a result the project could proceed without any construction delays caused by the consent and approvals process.

But it was not just people who were influencing the way the project was implemented. The dredging of the river section also had to accommodate the migration patterns of the Tyne's salmon population, which returns up the river to its spawning grounds—and a brooding seagull was able to delay demolition of a local pub by nesting in its chimney pot. Demolition work had to be put on hold until the young birds had flown the nest.

When the entire project is completed in December 2011, tunneling under the River Tyne will again have made history. The Tyne and Wear Integrated Transport Authority will have built one of its most advanced tunneling projects, and the people of Newcastle-upon-Tyne will see greatly improved mobility for many years to come. **R&B**

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